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ABSTRACT

This paper describes the Manifold Access Model, which has been developed for the simultaneous representation and analysis of the interrelationships between five variable clusters: (1) computer access; (2) personal and social attitudes and values with respect to computer use; (3) self-assessed competence and confidence with respect to computer use; (4) opinions of held stereotypes about computer use and users; and (5) perceptions of social issues and concerns accompanying widespread computer use. The validity and predictive utility of the proposed model with respect to school access is examined with data from a representative sample of over 2800 urban 16-year-olds from across Canada. The data showed that the variable clusters of the model (personal and social values, self confidence and competency, and attitudes) proved to be better predictors of access rather than such indicators as, for example, parents' education or student academic ability. The text is supplemented by four figures and two tables. (25 references) (Author/EW)

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A manifold Access Approach to the Portrayal of Computer-Young Person Interactions in a Social Context.

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ABSTRACT: The Manifold Access Model is developed for the simultaneous representation and analysis of the inter-relationships between five variable clusters: 1) computer access; 2) personal and social attitudes and values with respect to computer use; 3) self-assessed competence and confidence with respect to computer use; 4) opinions of held stereotypes about computer use and users; and 5) perceptions of social issues and concerns accompanying widespread computer use. The validity and predictive utility of the proposed model with respect to school access is examined with data from a representative survey of over 2800 urban sixteen-year olds from across Canada.

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The widespread use of microcomputers has influenced the classroom, the workplace, the home life and leisure pursuits of young persons. How can one characterize such computer use to take into account relationships between the conditions of human-computer interactions and the human interpretation of this interaction? In describing the relationships between the ways in which young persons experience computers and the related values held by these young persons, evidence suggests that levels of use may engender different attitudes toward computer use (Lloyd and Gressard, 1984). Because the notions of computer use and related values are varied and complex, an approach that allows for the simultaneous examinations of clusters of variables is indicated.

A model is presented here for the simultaneous analysis of a complex of inter-relationships of five hypothesized variable clusters: 1) computer access; 2) personal and social attitudes and values with respect to computer use; 3) self-assessed competence and confidence with respect to computer use; 4) opinions of held stereotypes with respect to computer use and users; and 5) perceptions of social issues and concerns accompanying widespread computer use. The validity and predictive utility of the proposed model is examined with data gathered in a representative national survey of over 2800 grade eleven (16 year old) students in 120 different high schools in all major urban centres in all the provinces of Canada.

To test the hypothesis that the kind of computer use may colour the character of human computer interaction as well as the interpretations of such interactions, the model was tested for males and females under the conditions of recreational, home task and school uses. It is beyond the scope of this paper to report on all such tests. What is reported here is a test of the model using the school access cluster as a "target". The background to the model and related data gathering instruments, the testing of the models using path analytic techniques and a brief discussion of the theoretical and educational relevance of the results are given below.

The Development of the Manifold Access Model of Human-Computer Relationships.

Studies to date on computer use in schools provide an incomplete picture of human-computer relationships. For example, some of these attempt to express this relationship in terms of a single measurment. However, in assessing the impact of computers on Canadian youth and in trying to understand the manner in which young persons value computers for themselves, for society, and for their futures, such as a single number quantification seems an over-simplification. It does not take into account the multiple factors suggested by Paisley (1985), nor does it account for the changing social and cultural patternsn which are accompanying computerization in our society, or the perspective needed to understand such changes (Cordell, 1985; Nora & Minc, 1981; Pask & Curran, 1982). In addition, such studies frequently have failed

to consider the type of computer use in which the human-computer relationship is taking place. Idhe (1979) has noted that human-computer interaction is a function of the context of the computer use. For example, learning with a computer in school or at home is a different context than using a computer as a personal tool or for recreational purposes.

There are numerous factors upon which one could base a theory of human-computer interaction and its interpretation by the human actors. Paisley (1985) sees demographic variables (including age, gender, school characteristics, SES, and parents' education), affective variables (beliefs about computers, evaluation and self-esteem in their presence), social variables (peer and parent values), and context variables (institutional or individual group use), as well as cognitive and particular computer configuration variables as critical in describing computer access by youths and the effect of this access. Among factors which influence computer access for secondary school students, Schubert (1986) lists policies, software selection, peer encouragement, and role of family and peers as critical.

In discussing computer access in this context, it might be simplest to consider access to computers as a function of two sets of variables:

- availability of computers (at home, school etc.)

- actual use of computers by young persons.

Even with this expanded perspective an interpretive model of access to computers and its effects must also take a variety of other dimensions of computer interaction into consideration. These other dimensions include the values adolescents carry toward their society in general and toward computer-related concepts and issues in particular. Also such a model should relate to the self-efficacy of young persons with respect to computers and to the relationships of this self-efficacy to present and future social values and concerns.

Valuing of computers, one's identification with computers and perceived competence in a computer society and perceptions of related social issues and concerns are coloured by one's feelings toward computers. Turkle(1984) suggest that such feelings are not general but are highly related to context. One common feeling manifesting itself in a variety of ways is intimidation or anxiety in the face of computer hardware and software and its use (Shore, 1985). Collis (1984, 1985) suggests such discomfort is more evident for young females than for males. Such personal discomfort might be a factor in what Collis describes as a "We can, but I can't" conceptualization of self-efficacy in the face of computers. Such sex differences in feelings toward computers and related self-efficacy are likely a complex phenomenon. Turkle (1984) also views computer mastery as having different possible forms. "Hard mastery" encompasses pre-planned work

stressing efficiency, power and top-down control. "Software mastery" occurs in response to computer work in progress and is characterized by its expressive nature. Different experiences in different computer environments will likely generate different levels and feelings of competence, control and frustration.

Whatever the use form, serious critics have suggested that uses of computers, particularly at the level of a computerized computer-accepting society, are destructive of human relationships and degrade culture. Heidegger (1977) considers the enframement of society by technology as limiting its vision, potential, and life. A symptom of this is seen by Weizenbaum (1976) where the individual in the society substitutes computation or information for judgement. Such action may lead to infringement of individual freedom. Shore (1985) is concerned that persons seem to be too ready to trust the authority of computers, while Shallis (1984) is of the view that humans, particularly in Western culture, are showing unwarranted faith in computer power. The social values which Canadian youth hold toward computers might be reflective of the nature of their access (growing up with computers) and may be indicative of possible future problems with respect to technological "enframements".

One enframement which may serve as a personal constraint in computer use and may also contribute to an improper valuing of computers in society relates to the stereotypes of computer use and users held by Canadian youth. Such stereotypes may have to do with the place of computers in society (work as opposed to personal) and the perceived future role of computers in a person's life. Sex differences (Ellis & Sayer, 1986; Lockheed & Frackt, 1984) in such stereotyping can arise and be personally enframing, particularly for women.

Computers users or use can be perceived as elitist (Matson, 1985), male or male-oriented (Collis, 1985), and users sometimes are regarded as social misfits (Turkle, 1984). Such stereotypes may constrain computer access for the holders or may lead to the artificial over-valuing or devaluing of computer use. A model of relationships between interaction and interpretation of computer use by Canadian youth should include held stereotypes as a variable constraining access and influencing values and concerns. Thus, a model of access which reflects both this complexity and this dynamic interaction is desirable.

The manifold model in Figure 1 depicts the interrelationships among access to computers, general values related to computers, stereotypes associated with computers and their use, and concerns about computers in society. These elements and their interrelationships within the context of gender, geographic base, and type of computer use are the objects of this study.

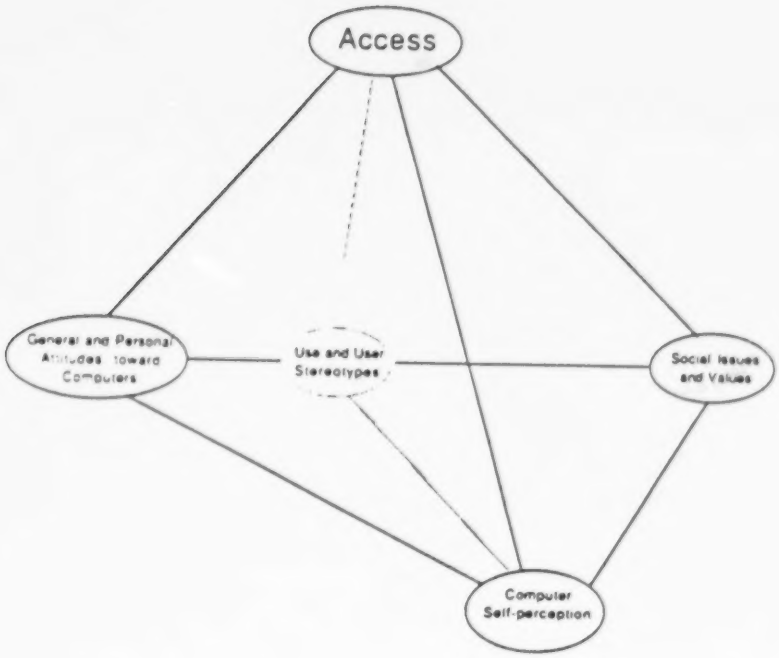

Figure 1. A Manifold Access Model of Human-Computer Relationships

The edges joining the nodes in Figure 1 should not be thought of as projecting from access to the other nodes. Rather, these edges could be better replaced by at least two oppositely oriented arrows indicating a sense of mutual causality (Maruyama, 1965) and systematic feedback among nodes. For example, one's in- or out-of-school access experiences may help create or maintain stereotypes held about one's self or about others as computer users. In turn, one's stereotypes about computer use and users may condition one's access (computers are for "egg-heads" or computers are too "unnatural", therefore, I do not wish to use them) and affect the quantity or quality of access.

This polyhedral complex of interrelationships, metaphorically termed a manifold, is based on the mathematical notion of a manifold which may be defined as "the natural state space of a dynamical system" (Devaney, 1986). There are at least two kinds of dynamics of such a manifold which are worthy of study. One can study the temporal or recursive dynamics of a system where the current state of a system is an input to itself in determining its temporal state. Such applications are found in physics and economics. One also can study the structural dynamics or the topology of the manifold at a particular time or set of times. In mathematics, such structural study has led to the development of fields such as algebraic topology.

In any mathematical dynamical system a change in parameters can bring about dramatic changes in the behaviour and even the structure of the system. Thus, it is useful in studying the polyhedral manifold of interrelated variables pertaining to computers and young persons described above to change parameters and observe changes in the topology or shape of the relationship complex. Such parametric changes can be based on who is using the computer (males versus females, younger adolescents, older adolescents, adults), the purpose of the access (differentiating computer access and accompanying personal responses according to recreational, task, or school use), or place of use. A manifold model approach allows for the characterizing of such computer-human relationships in social contexts and for the comparing of characterizations depending on the type of use and gender of user.

Each of the five nodes of the polyhedral manifold formed the basis of a subscale of a questionnaire. Detailed subscales dealing with access, self-assessment (confidence and competence), attitudes (personal values), held stereotypes, and social values and issues/concerns were developed and refined through a sequence of pilot tests to acceptable levels of reliability (0.75 - 0.85 for various subscales). In order to consider the relationships under different parametric conditions of access, subscales and related measures of values and attitudes were devised for each category of recreational, task and school computer uses. Questions providing context data (e.g. computer ownership, computer course participation, academic, and demographic items) were also generated.

After a series of three large validating pilot studies (Kass & Kieren, 1986), the questionnaire was administered during 1986/87 to over 2800 students in 120 Grade 11 social studies classes in the larger urban centres in Canada on a proportional basis, in French or English as appropriate. Because the data in this study are based on single administration, it is the internal structural rather than the temporal dynamics of the manifold model which is under consideration in the analysis. Path analysis is a suitable procedure in that it allows simultaneous examination of multiple relations of variables.

Testing the Manifold Access Model

To study the topology and relational-link strengths of the manifold model the polyhedron was "unfolded" into a two-dimensional set of paths with one node designated as a target node. Because access to computers by different groups for different purposes has important implications for educational and social policy and because the access variables may be viewed as more "factual" than the others, "access" was chosen as the target variable. For the purpose of this report the school access models are studied.

The relationship between the access and the other four variable sets in the model is characterized by a set of ordered paths leading to or predicting access. The variables are augmented by context variables (e.g. parents' education, computer ownership) by means of paths which may influence access directly or through a variable in the manifold model. Path analysis of a fully recursive model involving all possible paths and a reduced predicted model is used to ascertain the portion of the variability of the access variable explained by the model.

This analysis of the data is used to consider the following research questions:

1. One can think of school access to computers in terms of a cluster of "likelihood to use the computer at school" variables. How do social and personal attitudes, computer self-efficiency and perceived competence and held stereotype variables predict school access? What are the influences of such exogenous variables as parents' education or home computer ownership?

2. Are there gender differences in the topology or the link strength of the manifold access relationships?

Full Model for Predicting School Use of Computers

What are the factors associated with school use of computers? One could expect influences both internal to the manifold model as well as contextual or family influences. For example, parents' educational level and having access to a home computer

may be associated with a degree of computer familiarity and may also relate to the student's decision to study about computers in school as well as to the student's sense of self- confidence about computer use. Similarly, stereotypes about computer users may serve either as facilitators or constraints on decisions to study about or otherwise use computers in school. Certainly the number of opportunities that arise for the student to use a computer as a tool in regular classroom settings such as science labs, mathematics classes, as a writing tool in language classes, or for information access and display in social studies classes is likely to contribute to the student's interest in computers awareness of the value and application of computers in a number of different settings. Academic ability may also be related to school computer use if such use tends to be primarily the domain of students who take computer science courses or other courses with academic prerequisities.

Figure 2 shows the full model hypothesized to predict students' use of computers in schools. For clarity, paths associating every variable with every variable hypothesized to follow it in th model have not been drawn in; the full model predicts that the set of exogenous variables: parents' educational level, students opportunity to use computers within regular classes, students' own familiarity with computers through personal home access, students' academic achievement level, and stereotypes the students endorse about computers. All influence each of the six endogenous variables. The six endogenous variables are hypothesized to influence one another in the order shown in the model, with school usage the terminal variable in the model.

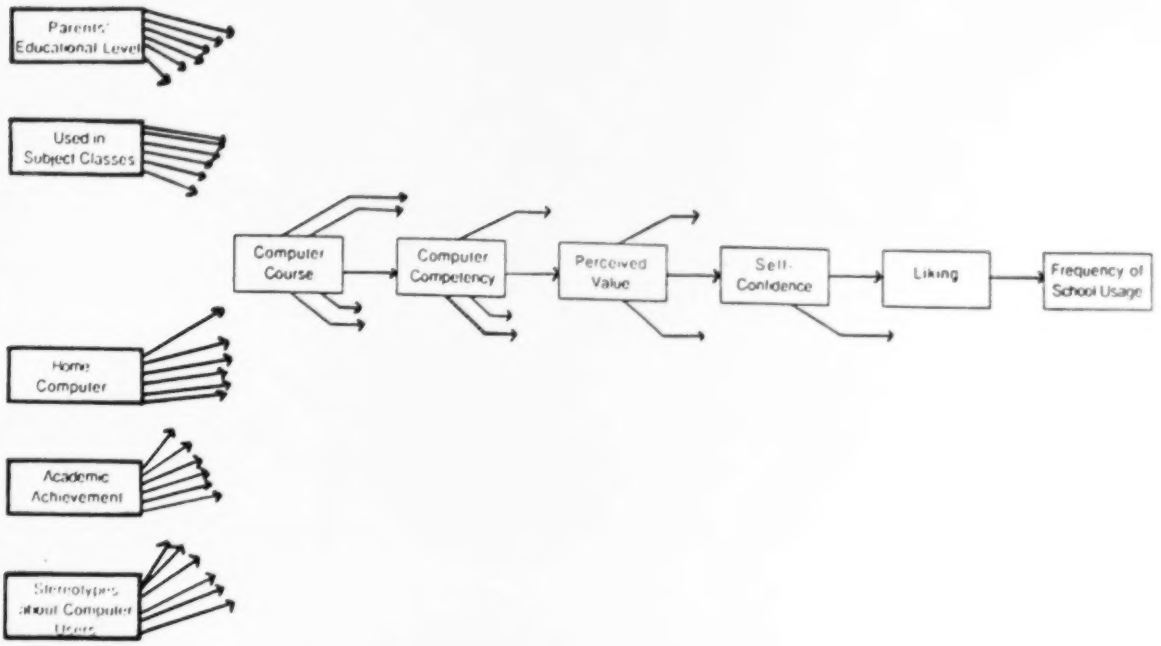

Figure 2. Full Model for Prediction of School Use of Computers

Fit of the Full Model to Data for Males and Females Relating to Use of School Computers

The model provides an extremely good fit for the prediction of school use of computers for both males and females, with the generalized regression coefficient for males equal to 0.979 and for females 0.976. Using the model, 62.8 percent of the variability in school use can be explained for males and 58.2 percent of the variability explained for females. Table 2 displays the path coefficients for the prediction of school use of computers using the full model. Because of the exceptionally

(INSERT TABLE 1 ABOUT HERE)

good fit of the model for the data for both the males and females, the full effects for each of the six endogenous variables are included.

It can be seen from Table 1 that both similarities and differences can be found in the influence of different variables on the prediction of males' and females' use of school computers. Contrary to prediction, parents' educational level has little influence and what influence it does have is largely negative -- the less educated the parents the more likely the student will use school computers. As predicted, academic ability has a positive relationship with the criterion variables, but this relationship is weak. Unlike expectations, stereotypes about computers contribute very little to prediction of the criterion variables in the model. Having a home computer is more definitely a predictor of school usage and other associated variables for males than it is for females. Taking a computer course is the strongest overall predict of school use for both males and females. The affective variables in the model -- perceived competence, perceived value, self-confidence, and liking -- contribute strongly to the prediction of all variables following them in the model, with perceived value of computer use strongly predictive of self-confidence about computer use for both males and females. This relationship is difficult to interpret and certainly was not predicted. Perceived value of computer use is more strongly related to liking for females than it is for males and is an important predictor of overall frequency of school use for both genders. Self-confidence predicts liking more for females than it does for males, but computer competency is a stronger predictor of variables following it in the model for males than it is for females. Liking has relatively little influence on school usage for either females or males.

Reduced Model for Prediction School Use of Computers for Males

While the full model presents a very good decomposition of the effects of different variables on the prediction of frequency of school use of computers, it is a highly complex model with 45 paths. A more parsimonious model with only 26 paths can be hypothesized for males. This reduced model for males is presented Figure 3 along with estimates of the relative strengths of

Table 1

Full Model Path Coefficients for Variables Involved in the Prediction of School Use of Computers

Criterion Variables	Predictor Variables										
	Residual	Parent Subject Use	Home Computer	Academic Ability	Stereotypes	Comp. Course	Comp. Competency	Value	Self-Conf.	Liking	
					Males						
Computer Course	.970[a]	.039[b]	.015	.117	.080	.039					
Competency	.490	.036	.145	.628	.080	.061	.283				
Value of School Use	.738	-.021	.216	.135	.130	.051	.339	.316			
Self-Confidence	.264	-.010	.207	.168	.172	.052	.398	.377	.714		
Liking	.604	-.047	.126	.103	.227	.125	.330	.367	.360	.481	
Frequency of School Use	.372	-.022	.259	.154	.090	.066	.510	.358	.437	.395	.157

(Table continues)

Criterion Variables	Predictor Variables										
	Residual	Parent Subject Use	Home Computer	Academic Ability	Stereotypes	Comp. Course	Comp. Competency	Value	Self-Conf.	Liking	
					Females						
Computer Course	.987	-.064	.101	.006	-.007	.015					
Competency	.561	-.014	.095	.596	.063	.093	.192				
Value of School Use	.783	-.040	.222	.021	.073	.064	.345	.259			
Self-Confidence	.248	-.037	.233	.048	.100	.066	.363	.292	1.243		
Liking	.541	-.171	.182	.010	.173	.151	.300	.301	.475	.568	
Frequency of School Use	.418	-.137	.202	.012	.025	.034	.558	.270	.421	.368	.179

Note. [a]Percentage not explained by the model.

[b]Standardized beta weights for prediction of criterion variables.

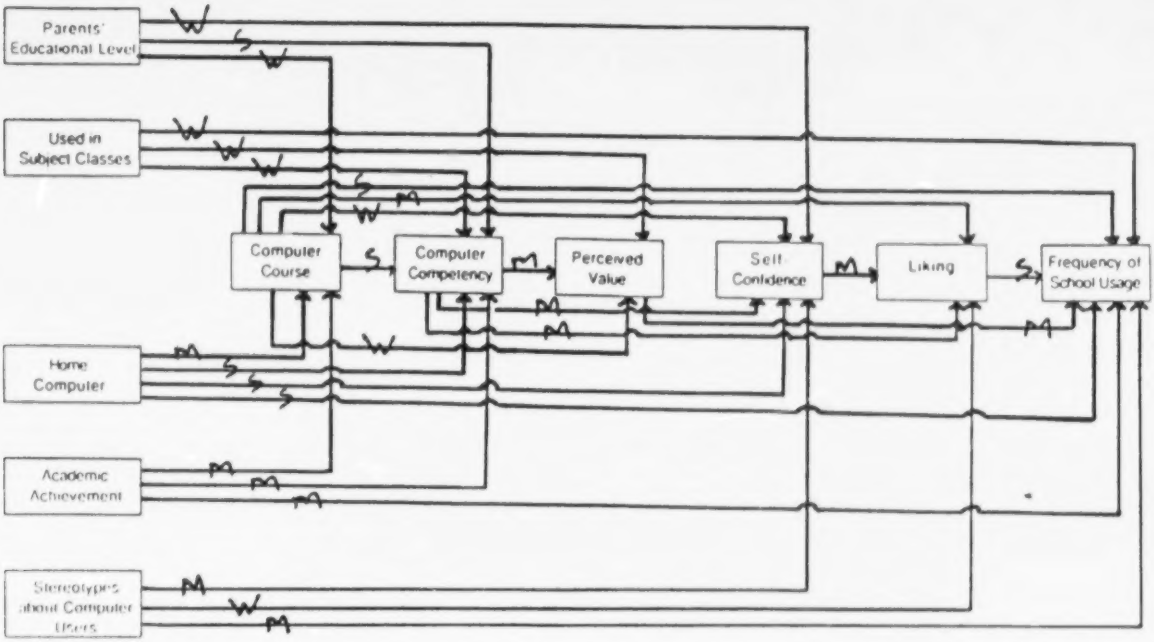

Figure 3. Hypothesized Reduced Model to Predict Use of Computers at School for Males. Labels indicate predicted relative influence of paths (W = weak, M = moderate, S = strong).

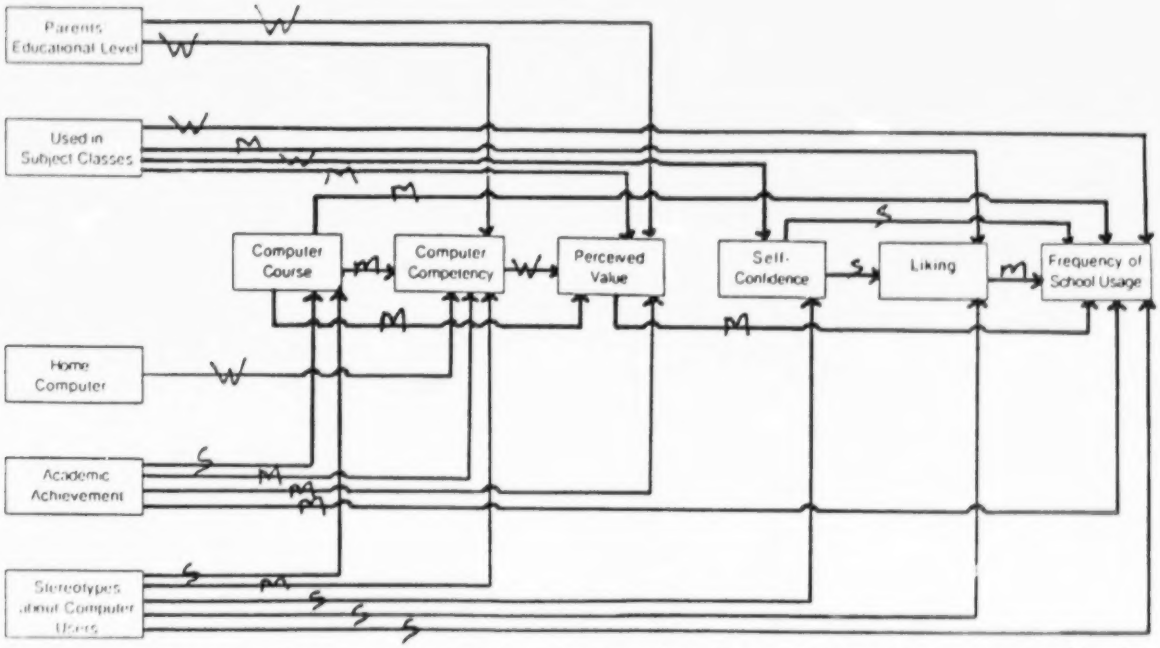

Figure 4. Hypothesized Reduced Model to Predict Use of School Computers for Females Predicted relative strengths of paths for females given by labels W, M, and S (weak, moderate, strong).

the retained paths. The reduced model for males reflects the assumption that males' use of computers is most strongly influenced by their out-of-school experiences with computers as well as by their decision to participate in computer science courses at school. Labels indicating the hypothesized relative strengths of each of the paths for prediction of males' use of school computers are given on Figure 3 and repeated for convenience in Table 2 along with path coefficients for the model obtained for the data for both males and females.

Fit of Reduced Model for Males for Prediction of School Use of Computers

The reduced model for males, with 19 fewer paths than the full model, provides a good fit for the data for males, R2 = 0.939. Compared to the full model which explained 97.9 percent of the variability in school computer usage for males, the reduced model for males loses relatively little in predictive power but gains considerably in terms of explanatory value for the model. The model for males also fits the data for females well, with a generalized regression coefficient of 0.914. However, a comparison of the fit of the data for males compared to its fit for the data for females can be expressed by a Q value of 0.709. (Q = 1-R2 Full/1-R2 model) supporting the hypothesis that the assumed predictors most influential for males are not the same or are not weighted the same as those that predict females' use of school computers. Females appear to most differ from males on the influence of a home computer on school use and on the impact of computer course experience and perceived competency on self-confidence. These relationships are stronger for males than they are for females. Hypothesized relative strengths were overestimated for males on: the influence of parents' educational level on computer competency; the effect of a home computer on self-confidence and frequency of school use; the effect of academic ability on likelihood of taking a computer course, competency, and frequency of school use; and the impact of stereotypes on self-confidence and frequency of school use. There were also some estimates that were underestimated. These include the influence of subject use of computers on perceived value and self-confidence; and the influence of competency on self-confidence.

Reduced Model to Predict Use of School Computers for Females

While the model for males to predict school usage of computers was based on the assumption that males are reasonably likely to make a straightforward transfer of their background and experience with computers into their likelihood of making use of school computers, it is reasonable to predict that females may mediate this transfer with a larger effect related to affective influences, such as stereotypes of computer users and personal self-confidence. There is evidence from research relating achievement and self-confidence for females in a variety of areas that suggests females are more likely than males to base their sense of self-confidence not on their own actual performance, but on preconceived opinions about their general competency. Thus the reduced model to predict use of school computers by females predicts less influence of experiential variables than is predicted in the reduced model for males and more influence of stereotypes and self-confidence variables. The model for females with predicted relative strengths of path coefficients is shown

Table 2

Path Coefficients on Hypothesized Reduced Model for Males to Predict Use of School Computers for Males and for Females.

Criterion Variables	Predictor Variables										
	Residual	Parent	Subject Use	Home Computer	Academic Ability	Stereo-types	Comp. Course	Comp. Competency	Value	Self-Conf.	Liking
Males											
Computer Course	.972[a]	W.038[b]		M.122	M.084						
Competency	.493	S.034	W.141	S.813	M.093		S.178				
Value of School Use	.753	(.020)[c]	W.205	(.201)	(.049)		W.339	M.260			
Self-Confidence	.673	W.007	(.061)	S.193	(.068)	M.082	W.610	M.658			
Liking	.617	(.011)	(.046)	(.174)	(.053)	W.042	M.339	M.323		M.516	
Frequency of School Use	.409	(.022)	W.229	S.195	M.041	M.005	S.509	(.178)	M.380	(.127)	S.246
Females											
Computer Course	.997	-.057		.009	.002						
Competency	.569	-.008	.114	.600	.069		.207				
Value of School Use	.798	(-.019)	.183	(.114)	(.014)		.347	.186			
Self-Confidence	.773	.001	(.041)	.053	(.025)	.030	.379	.356			
Liking	.558	(-.009)	(.032)	(.073)	(.020)	.018	.314	.283		.609	
Frequency of School Use	.440	(-.030)	.114	.064	.026	.036	.563	(.132)	.320	(.157)	.257

Note. [a]Percentage of variance not accounted for by the model.

[b]Standardized beta weights.

[c]Values in brackets are indirect effects not predicted by male model.

Letters relate to hypothesized relative strengths of the paths for males.

in Figure 4. The reduced model for females has 21 fewer paths than the full model for prediction of school usage of computers.

Fit of the Reduced Model for Females to Predict School Use of Computers

The reduced model for females provides a good fit for the data for females with respect to predicting school use of computers, with a generalized regression coefficient of 0.900. This compares favourably to the coefficient of .976 obtained for the females on the full model. However, it is not as good a fit for the females as was the reduced model for males (with R^2 = .914 for data for females on the model for males). The model for females also provides a good fit for the data for males and in fact, the data for males fit the model for females (R^2 = .917) better than the data for females fit the model for females. However, the model for males provides a better fit for th data for males (R^2 = .939) than does the model for females. While the details of the analysis are not presented here it is interesting to note the following findings. As predicted, self-confidence is the major predictor of both liking and frequency of the use of computers in schools. Data for males fit the model in the same ways with only one notable exception -- taking a computer course was a moderate predictor of school computer use for males but a suppressor of use for females, as shown by a path coefficient of 0.313.

Summary of Prediction of School Use of Computers

The so-called model for males for prediction of school use of computers provides a very good fit for the data for both the males and females and facilitates interpretation of the frequency of this usage through its omission of 20 paths from the full recursive model while losing only 4 percent in predictive power for males and 6.2 percent for females. This model emphasizes the impact of prior experiences with computers in the school and the perceived value of computer use as the two variables most strongly associated with the likelihood of school use of computers. This model of school computer access does not support more than weak predictive power for parents' educational level, students' academic level and held stereotypes of computer users. Finally, as predicted, having a home computer contributes significantly more to the likelihood of male school computer use than for female use, although these relationships are at best moderate.

Discussion

The concept of a manifold provides a theoretical and a methodological technique for studying the complex phenomena of school computer access and the interpretation of such use by young persons. The analysis here suggests that variable clusters from the Manifold Model (personal and social value of the use, self-

confidence and competency and attitudes) affect likelihood of school use as do previous school experiences. In fact, these variable clusters prove to be better predictors of access than are, for instance, parents' education or student academic ability.

Although it is beyond the scope of this paper to present the details, analysis of home task access and recreational access models suggests that the "topology" of the manifolds for school use, home task use and recreational are very different. Thus, in assessing the effects of computer use on young persons it appears critical to differentiate among use types.

The data presented here, as well as the data from the other access type models, also have an impact on the discussion of gender differences in computer access and impact. The "topologies" of the access manifolds, that is, whether particular variable clusters predict access, are similar for males and for females. What is different is the strengths of the particular links between variable clusters.

Finally, the data and the analysis here suggest that school computer use differs significantly from home use in character. Because so many students have computers at home - about two fifths in the sample discussed here (Kass, Kieren, Collis, Therrien, 1987) - it is important to determine if home computer use has a dominant impact on school use. While the data indicate a moderate impact, particularly for males, other school experience and self-efficacy and attitude variables seem to play a relatively stronger role in school access. Thus school use of computers may be reaching different students in different ways than home use, supporting the push to have students use computers in schools.

One of the impacts of school experience in general is on the values and concerns that students hold for society. Because the manifold access model has demonstrated predictive validity in predicting school access, the model can now be unfolded using social concern as a "target". The relative impact of school access as it relates to held concerns of students can then be tested.

Thus it would seem that, in theory, in methodology, and as a means of considering educational and social implications of computer use by young persons in school and other settings, the Manifold Access Model holds promise as a means studying interactions among critical variable clusters in a complex, not strictly linear manner.

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